6.0 WIPE VERSUS VACUUM COMPARISON

The two major HUD programs investigating levels of lead in household dust utilized different sampling methods. In the Demonstration Study, dust was wipe sampled. In the National Survey, dust was vacuum sampled. As part of the CAP Study, several side-by-side dust samples were taken by the wipe and vacuum sampling methods. This chapter presents a comparison of both the wipe and vacuum sampling methods. The methods are compared across all substrates and by substrate.

To investigate the relationship between lead loading determinations made by the two methods, four side-by-side samples were taken from a selected room in each abated house. Two of the samples were taken by the vacuum method and two by the wipe method. Samples were collected in 34 of the 35 abated houses sampled. In one house (House 61), all floors were carpeted so no wipe/vacuum comparison samples were taken. In another house (House 50), the substrate for one of the vacuum samples was half linoleum and half concrete, so this house was included in the comparison of methods pooled across substrates, but excluded from the analysis by substrate. Of the remaining 33 abated houses, one of the comparison samples in house 21 was lost during analysis. This also happened to be the only house in which both the wipe and the vacuum comparison samples were taken from a concrete floor. The three observed loadings were substantially higher than corresponding measures in all the other houses. The analysis was performed both with and without the data from this house. The results were only slightly different when this house is excluded, but due to the imbalance it was excluded from the calculation of the results provided below.

The geometric means of the paired floor lead loadings are listed in Table 6-1 and plotted in Figure 6-1. In the figure, lead loadings from vacuum samples are plotted versus lead

loadings from wipe samples. A solid reference line which represents complete agreement between the two sampling methods is

Table 6-1. Vacuum versus Wipe Comparison Data: Room Geometric Mean Floor Lead Loadings (ug/ft²)

Substrate	Unit	Location	Vacuum Loading	Wipe Loading
Concrete	21	LDY	4075.33	333.56
Linoleum	93	KIT	6.07	3.96
	44	HAL	3.89	3.84
	25	KIT	2.84	3.56
	96	BAT	38.93	10.41
	46	BAT	0.85	18.07
	77	KIT	5.63	6.85
	7	KIT	26.77	7.34
	18	KIT	34.81	5.82
	69	KIT	51.23	4.00
	70	KIT	1.03	5.18
	80	KIT	980.96	21.10
	10	KIT	11.83	7.37
	40	BAT	1.03	4.83
	50*	BSM	4.57	5.57
	71	KIT	21.35	23.31
	81	KIT	3.47	39.70
	31	HAL	87.02	52.69
	41	KIT	2.17	7.30
	72	KIT	1.55	6.94
Tile	47	BA2	1.14	2.86
	9	KIT	3.19	13.37
	90	KIT	552.54	69.37
	60	KIT	2.06	3.64
	51	KIT	5.24	13.05
Wood	74	BD2	48.26	45.11
	84	KIT	195.17	14.76
	94	KIT	27.06	26.92
	24	LDY	206.14	4.24
	55	LVG	10.53	10.56
	17	LVG	104.66	6.26
	99	DIN	175.91	24.71

	39	KIT	11.24	26.61
	11	DIN	183.66	28.97

* The substrate for one of the vacuum samples collected at this house was half linoleum and half concrete. Therefore, this house was excluded in the estimation of multiplicative biases by substrate.

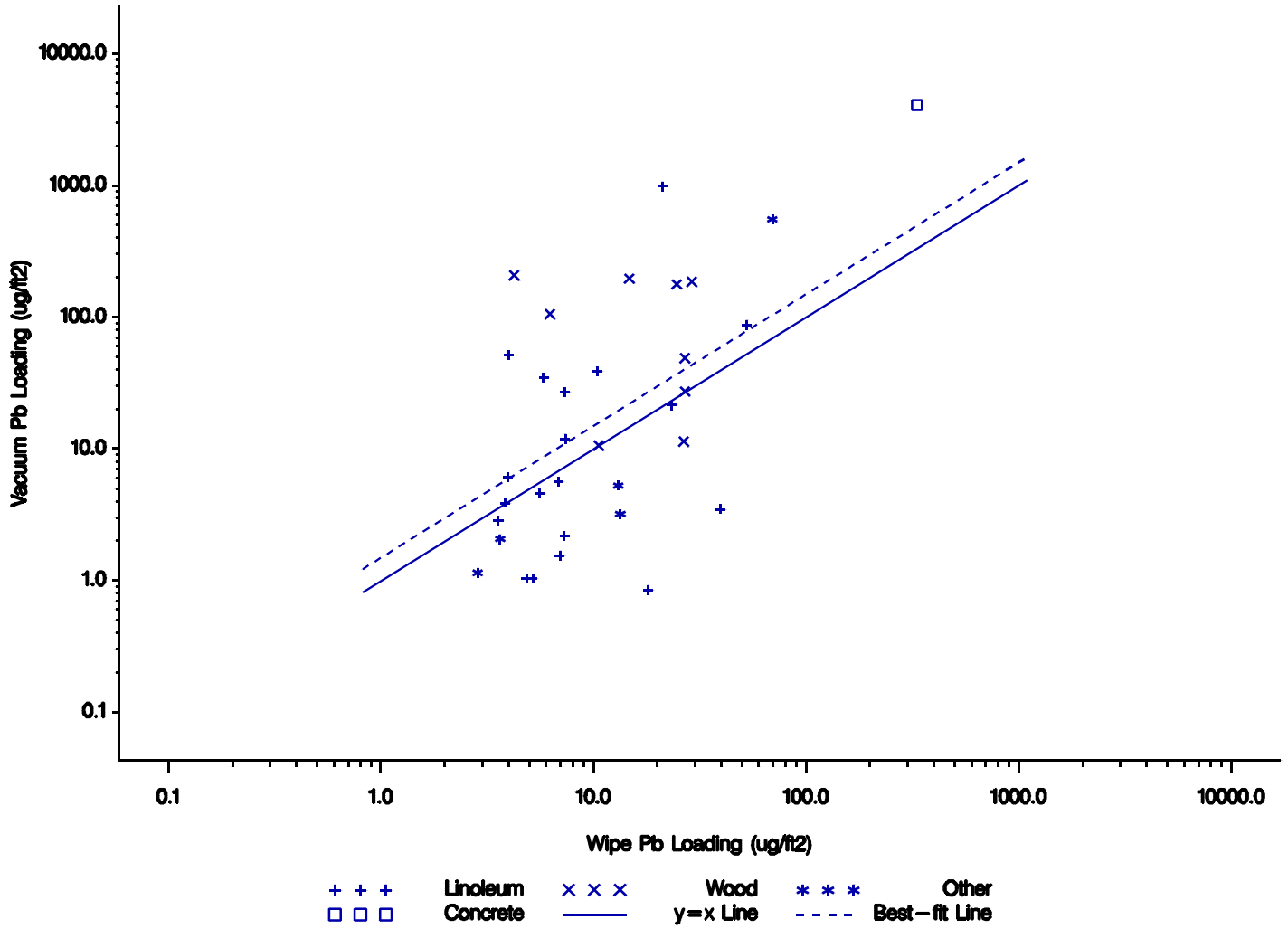
10000.0
1000.0
100.0
10.0
1.0
0.1
Vacuum Pb Loading (ug/ft2)
0.1
1.0
10.0
100.0
1000.0
10000.0
Wipe Pb Loading (ug/ft2)
Linoleum
Concrete
Wood
y=x Line
Other
Best-fit Line

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Figure 6-1. Vacuum versus wipe comparison: geometric means of side-by-side floor lead loading (µg/ft²) measures. (Estimate of vacuum/wipe ratio is 1.38; confidence interval is (0.75, 2.54).)

also plotted along with the best fit regression line. A statistical analysis was performed to quantify this relationship. This is discussed in Section 6.1. Samples taken on different substrates (linoleum, wood, concrete, or tile) are distinguished by different plotting symbols in Figure 6-1. Since the relationships between vacuum and wipe responses were different for each substrate, the analysis was also performed adjusting for substrate. This analysis is discussed in Section 6.2.

The effect of room type on the wipe/vacuum relationship was also investigated. Categories such as wet versus dry and eating versus non-eating were considered. No significant differences were observed.

6.1 ALL SUBSTRATES COMBINED

It was assumed that the relationship between vacuum and wipe measures is log-linear:

$$\log(V) = \log(\alpha) + \beta \log(W) \qquad (1)$$

where V and W represent the true expected loadings by the vacuum and wipe methods. Restating the model in terms of the untransformed loadings gives

$$V = \alpha W^{\beta}. \qquad (2)$$

If β is not equal to one, the multiplicative bias between the two sampling methods changes with the magnitude of the measurements. However, if $\beta=1$, there is a fixed multiplicative bias (α) between the sampling methods which does not change with the magnitude of the measurements. Also, for $\beta=1$, the model of Equations (1) and (2) simplifies to the assumption that the ratio W/V follows a lognormal distribution with geometric mean α.

Since the vacuum and wipe determinations are both measured with error, a simple linear regression for (1) is inappropriate. An errors-in-variables approach was used. Specifically, V and W in (1) are not observed, but rather V* and W* where

$$\log(V^*) = \log(V) + \log(,), \text{ and}$$
$$\log(W^*) = \log(W) + \log(*),$$

with , and * independent and lognormally distributed. Using simple linear regression produces biased estimates of " and $. However, formulas to correct for these biases are known (See Draper and Smith, 1981, p. 123), and were used in the results that follow.

All of the data described in Table 6-1 was used in this analysis except for those samples collected on concrete (House 21). Thus 33 pairs were used. The first step was to test the hypothesis of a fixed multiplicative bias (H_o:$=1). The estimate of $ was 1.32 with a standard error of 0.43. Since the hypothesis could not be rejected at any reasonable significance level (p=0.46), the model was then refitted with the $ parameter set to one. The estimate of the multiplicative bias (") of vacuum over wipe measurements is 1.38 with a 95% confidence interval of (0.75, 2.54). This result implies that, on the average, vacuum lead loadings are 1.38 times larger than matching wipe lead loadings on floors.

The precision of the vacuum and wipe measurements is also a relevant quantity. On average, side-by-side vacuum measures were significantly more variable than wipe measures. The estimated log standard deviation for vacuum samples was 0.96 with a 95 percent confidence interval of (0.77, 1.26) whereas for wipe samples it was 0.55 with a 95 percent confidence interval of (0.45, 0.73).

6.2 ADJUSTING FOR SUBSTRATE EFFECTS

The above approach was used to investigate the vacuum/wipe relationship separately for each of the substrate categories sampled. For each of the substrates, the hypothesis of a fixed multiplicative bias ($=1) could not be rejected at any reasonable level. For each substrate separately, multiplicative bias estimates were derived assuming $=1. There was only one set of side-by-side comparison samples taken on concrete, so no estimates are provided for this substrate. Also, in one house (House 50) it was not possible to collect four side-by-side samples from entirely the same substrate. Three of the samples were collected on linoleum but half of one of the vacuum samples was collected from concrete. Therefore this sample was deleted from the analysis for linoleum samples.

The estimated biases vary according to substrate. There appears to be a relationship between the smoothness of the substrate and these biases. Table 6-2 displays the estimated multiplicative bias for each substrate along with confidence bounds. The ratio observed on wood was different from the ratios observed on both linoleum and tile, although the confidence intervals overlap. The bias appears to increase with coarseness of the substrate. If the wipe method fails to extract dust particles embedded in recesses on the substrate surface then this relationship would be expected.

Table 6-2. Vacuum/Wipe Multiplicative Bias Estimates

Substrate	Sets of Observations	Estimated Vacuum/Wipe Multiplicative Bias	Lower Confidence Bound	Upper Confidence Bound
Tile	5	0.69	0.12	3.90
Linoleum	18	1.02	0.42	2.44
Wood	9	3.92	1.13	13.59